THE EXPERIMENTAL METHOD*

AT A DINNER party a few weeks ago, after I had offered a conditional answer to a question, one of the ladies said, somewhat impatiently, "Oh, you scientists are never sure of anything." Although my reply, "In that, of course, we differ from philosophers," disposed of the matter for the time being, I have been brooding about it ever since. In the first place, I had not been quite fair to philosophers. I am sure that the philosophers in the audience will realize, however, that to qualify that remark would only have emphasized for my critic my fundamental uncertainty, and also would have lessened its value as repartee. Moreover, philosophers are inured to sweeping generalizations; in fact, it forms much of their subject matter. What has bothered me most is that the question under discussion was not scientific but political, about as far from science as you can get; it was certainly controversial, and yet my hesitancy was attributed to my scientific training or occupation.

The desire for certainty and its corollary, security, is a quite understandable reaction to the intellectual and physical turmoil of our times. It is regrettable, however, that the experimental and self-correcting techniques of science and the emphasis on relativity, statistics, and probability have caused a popular identification of experimentation and science. On the one side this has led to a distrust of scientific methods in fields where experimentation is difficult or not possible; on the other it has led people to look to non-scientific fields for the certainty they seek. Each of these is dangerous in its own way. Distrust of scientific methods leads

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to anti-science; the search for certainty leads to traditionalism or authoritarianism. Both together lead to stagnation and tyranny.

Although the basis of the desire for certainty is understandable, to demand it at all times is a sort of madness. One can achieve certainty in only two fields—theology and mathematics. In theology it is because the fundamental premises are by definition superhuman and supernatural and therefore not susceptible to human doubt or to verification in nature. God can test the faith of man by martyrdom, but man cannot challenge God to prove his Deity by a miracle. In mathematics one has certainty for similar reasons, because the fundamental premises of a mathematical system need have no relation to man or to the physical world; they are extra-human, and extra-natural. An intuitive popular awareness of these qualities of theology and mathematics has probably given rise to the saying that "Nothing is certain but death and taxes!"

To attempt to discuss methods of resolving uncertainty within the bounds of a brief talk would be foolishness. According to Bertrand Russell, "To endure uncertainty is difficult, but so are most of the other virtues. For the learning of every virtue there is an appropriate discipline, and for the learning of suspended judgment the best discipline is philosophy." I do not wish to tamper with your virtue even though it may be a virtue of necessity. I intend rather to make a plea for providing opportunities to cultivate that virtue.

Uncertainty can exist only where there are alternatives. In many cases, perhaps in most, one is confronted by alternatives. The need for decision is forced upon one as a prerequisite to immediate action. But wherever there has been the opportunity, wherever there has been the time, creative

man has liked to experiment, to present himself with material for choice.

Because of the great advances in physical science and industry during the past hundred and fifty years, change is often identified with a technological change, experiment with scientific experiment. In reality, it is the artist rather than the scientist who is the apostle of experiment. For the artist seldom receives his inspiration fully grown. Manuscripts of poems are full of erasures and substitutions. Notebooks of composers show many changes and reconsiderations. Creative artists are not usually very articulate about their techniques, but occasionally one does give us an insight into his methods. Joseph Haydn, for example, was for about thirty years attached to the court of Prince Esterhazy. He had an orchestra at his disposal at all times and he could—I quote from his own words—"make experiments, observe what produced an effect and what weakened it, and was thus in a position to improve, alter, make additions or omissions and be as bold as I pleased." The fruit of all this has only recently been made available to us through phonograph records. The fifty-odd symphonies written during that time show a variety of form and content, while maintaining an almost uniform excellence, that is matched by no other composer. The study of the development of Haydn during this period is a fascinating adventure. Someone once called Haydn the "unknown" composer. To the non-professional musical public he was known as the composer of about twenty symphonies, peculiarly numbered, starting with No. 88, all of which are smooth, polished, and perfect, and to me a bit dull.

The enthusiasm of a group of scholars and musicians and the development of the high-fidelity tape recorder and of the long-playing record have made available within the past two years practically all of the symphonic and choral works

of Haydn in superb performances, adhering as closely as possible to the instruments of Haydn and to the style of performance of the time.

These reveal an enormously experimental Haydn, a composer who was not satisfied with the existing forms, or with the instruments used, or with the relationship of music to emotional content. The works of this middle period of Haydn's life are to me profoundly more interesting and aesthetically satisfying than the later works. The symphonies are greater than those of any other composer with the possible exception of Beethoven, and if quality is multiplied by quantity, Haydn is way ahead. His choral works are second only to those of Bach and his chamber music is surpassed only by that of Beethoven.

Perhaps it is only a personal idiosyncrasy to find a greater interest in and attach a greater value to works which show experimentation, intellectual curiosity, and technical development than to products of symmetrical perfection. On the other hand, one finds that in many primitive tribes artists and craftsmen deliberately introduce imperfection. In Navajo blankets, for example, one can always find a flaw or lack of completeness in the design. Anthropologists give a theological explanation for this, that it is believed that when one has accomplished a perfect work, one's life's task is done and there is nothing left to do but die. It is not infrequent, however, that theological explanations are rationalizations of conduct otherwise explainable, and I wonder whether a tendency to strive for perfection rather than attain it may be a fundamental characteristic of the human race.

We know, too, that painters change and revise; but is that experimentation? Evidence that it is comes from their writing, too. For example, in a short essay Paul Klee, Swiss-born artist who died a short time ago, tries to explain the method

and meaning of modern art. He points out the various self-imposed rules of procedure and the basic elements (such as form and line and color) of which a work is composed and then goes on to say: "While the artist is still exerting all his efforts to group the formal elements purely and logically so that each in its place is right and none clashes with the others, a layman, watching from behind, pronounces the devastating words, 'But that isn't a bit like uncle!' The artist if his nerve is disciplined, thinks to himself, to hell with uncle . . . I must get on with my building . . . This new brick is a little too heavy and to my mind puts too much weight on the left. I must add a good sized counterweight on the right to restore the equilibrium. And he adds this side and that until finally the scales show a balance."

Obviously, then, experimentation is not the exclusive property of scientists, but equally obviously it is always the enemy of dogma and fanaticism. It is no mere coincidence that in Russia music has recently shared with genetics the spotlight of Kremlin disfavor, or that in Nazi Germany "decadent" art and "non-Aryan" science were equally enemies of the state. Many "capitalist" practices have been adopted in Communist business and industry but art and science must be kept pure.

Experimentation and progress are not only enemies of autocracy; they are part of the essential nature of democracy. The meaning of democracy is not simply the etymological "rule by the people." It implies a divergence of opinion as well. The Soviet use of the word as in "the people's democracy" is meaningless as well as redundant. If the people were all of one mind, as is presumed in Russia, then there is no need for democracy. Any individual member of the people could rule and autocracy, oligarchy, and democracy would be synonymous and identical. Modern democracy

is a form of government which permits of change and progress in a way satisfactory to the majority of the people. Eliminate experimentation, eliminate variety of belief and opinion, and there can be no democracy. Where there is no choice to be made and recorded, why go through the forms of choosing and voting?

Other than dogma, the principal competitor of experiment is past experience. Why risk error and heresy by experimentation when one can study the experiments of the past and learn from them? There are two fallacies here. The first is that we know what has really happened in the past. The testimony of witnesses after an accident, the divergencies in accounts of important conferences, show that even with regard to the very recent past, and even with the evidence of eyewitnesses, it is not easy to reconstruct what has happened. The task of the historian is not an easy one. He must reconstruct from hearsay, from allegorical works of art, from fragments of physical objects, not only the acts but the motives of people and societies which may be as far from his own in ways of thought and action as is the primitive savage. See how hard it is for us to understand why the Russians act like Russians. And how hard it seems to be for them to understand that their tactics are such as to cause us to react in a way contrary, or so we suppose, to their interests. George Santayana, surely no radical, points out that, "Inferred past facts are more deceptive than facts prophesied, because while the risk of error in the inference is the same, there is no possibility of discovering that error; and the historian, while really as speculative as the prophet, can never be found out."

The second fallacy is the greater one, that the world is static, that problems are always the same, that the solutions are timeless. Historians who develop cyclical theories of

history prove only that they are reasoning in circles. To say that there is nothing new under the sun or *plus ça change, plus c'est la même chose* is only sophistry. There is unfortunately no lack of proponents of the theory that everything was known to the ancients, at least to the wisest of the ancients. I even know one man who about fifteen years ago got a Ph.D. in philosophy for a thesis which developed the equations of modern physics in the terminology of Aristotle. I should like to see how he would describe the synthesis in the uranium pile of the element plutonium, which never existed before.

Even physical experiments must be repeated occasionally because instruments have been improved, particles thought to be elemental are found to be complex, variables considered irrelevant turn out to be important. Experiments in fine art are repeated with variation in pigments or in other media. Duco lacquer and lucite, commonly used in modern art, were not available to Leonardo da Vinci.

Not only do techniques and media change; criteria do as well. That is not so much so in physical science, where the objective is always a better explanation of the constitution and behavior of matter, and where the criteria are those set up by scientific method, logical consistency, completeness, and simplicity (in a formal sense). In art, however, the criteria are aesthetic and aesthetic standards change with fashions, economic conditions, and type of government. And in the social sciences as well, the standards of the past may no longer be valid. Can one, for example, have the same kind of social structure in a country or period where the life expectancy is 65 years as in one where it is 40 years? The increasing proportion of older people in a society makes it necessary to consider new problems, how to employ them usefully, how to provide for them when indigent. Some of

the most important problems in medicine, problems which are deeply involved with social problems, are being studied in the new science of geriatrics, the care and treatment of diseases and infirmities associated with aging.

There is another and more serious objection to experimentation outside of the arts and the physical sciences, but before discussing that I should like to talk a bit more about the nature of experiment itself.

In most lecture rooms the seats are so uncomfortable that the speaker is challenged to keep the audience so interested that they do not fidget. I know from experience that the seats here are so comfortable that there is no need to fidget and the challenge to the lecturer is rather to keep the listener from yielding to complete relaxation. Nevertheless I am afraid I may have given some reason for mental fidgeting. I have been talking about experiments and the experimental method without defining my terms. You may properly be asking what is an experiment; isn't any action an experiment; or, at least, isn't the method of "cut and try" the experimental method?

Usually the dictionary is not of much help in matters of this kind. Remarkably, however, it is here. According to the Merriam-Webster unabridged dictionary, an experiment is "A trial or special observation made to confirm or disprove something doubtful, especially one under conditions determined by the experimenter; an act or operation undertaken in order to discover some unknown principle or effect, or to test, establish, or illustrate some suggested or known truth."

The difference, then, between experiment and a trial, between the experimental method and the "cut and try" technique, is that experiment involves a close relationship with a theory. Theory and experiment are not rivals. They

are essential complements to each other. And the difference between the dogmatic approach to problems and the experimental is that the experimental always involves an uncertainty, a tentativeness. Properly planned experiments have double objectives: the first of course is to see whether they corroborate the theory; the second is to suggest an alternative theory if they do not check the original one. In fact, when the experimental method is used as part of the scientific method, it involves the use of crucial experiments designed to disprove the theory if the theory should be wrong.

There are, however, some very important differences in experimentation in the physical sciences and the arts and experimentation in other fields, particularly in the social sciences. To understand them it is desirable to examine in more detail the kinds of experiments that can be performed, specifically with regard to the relationship between the experiment and what is being experimented on, which I shall call the subject of the experiment.

The first type of experiment is pure observation. In this the experiment has no effect on the subject or the condition of the subject. Examples of such experiments are readily found in astronomy. Recording and measurement of the wave lengths of spectral lines from distant stars are very important in the determination of the temperature and composition of these stars, and of their motion relative to the earth. These experiments have no effect whatsoever on the stars, not only because of their distance but because the light being studied now left the stars many years ago. Other examples of like types of experiments will undoubtedly occur to you. They can be found in meteorology and in geology, for instance. Measurements of rainfall cycles or temperature cycles, of the chronology and duration of geological eras, have no conceivable effect on the subject.

Note, however, that the examples I have given involve subjects that either are very distant, in space or time, or are so massive that man's puny efforts cannot influence them. More often there is some interaction between the observer and the subject. This brings us to the second type of experiment, in which the purpose is pure observation without affecting the subject but in which there is interaction between the two.

The most obvious and clear-cut examples of this type of experiment are found in psychology. You all know how children, dogs, or monkeys act up when they know they are being observed, so that in studies of behavior of individuals or groups it is necessary to use one-way screens, behind which the observer can sit and watch without being seen by the subject, or even to use elaborate remotely controlled photographic and recording devices. This type of experimental problem is not unique to psychology or to biology or other studies of sentient beings. One finds it in physics as well. The by now notorious and much misapplied uncertainty principle essentially states that because of the interaction of the measuring system and the subject, the position and momentum of an elementary particle cannot be determined simultaneously and yet exactly.

There is also an interesting variation of this interaction phenomenon in which the subject is not affected by the observation but the observer may be. That happens, for example, in dealing with radioactive substances where very elaborate arrangements must be made for remote observation. Of course the classic example of this is the case of Lot's wife.

It also seems to happen to Communist observers of capitalism. Many onetime prominent diplomatic figures from Russia have disappeared from sight, and it is said that soldiers exposed to the corrupting influence of contact with the West

are never returned to their homes but are sent to locations remote from centers of population.

The third and largest class of experiment is that in which the environment of the subject is changed under the control of the observer. Most chemical experiments are of this kind and practically all of the experiments in the fine arts are also. That is what the painter does when he varies color relationships of objects on his canvas or balances forms against each other to determine optimum composition. When this kind of experimentation is tried in the nonphysical sciences there are sometimes serious complications. There is a famous case of a study of the effect of working conditions on the morale and efficiency of workers, which was made at one of the manufacturing plants of the General Electric Company. Everything was done in a very scientific manner. The workers were divided into two groups. One was to be a control and was left alone to continue work as usual. The other was subjected to a number of changes in environment. The density of lighting was increased. The efficiency of the workers went up. The shop walls were painted in pleasant pastel colors. The efficiency of the workers went up. Music was provided during work. The efficiency went up. Rest periods were given every two hours. Efficiency still went up. The results were so remarkable that someone got suspicious and decided to see whether these effects were reversible. The The density of lighting was diminished. The efficiency of the workers went up again. The music was stopped. Still the efficiency went up. Admittedly the magnitudes of the increases could not continue to be large indefinitely but the direction was definite. After a lot of head scratching and additional experimentation, which included talking to the workers as people instead of just observing their output, it was found that the most important factor in improving morale

and efficiency was the pleasure of the workers in the fact that someone was paying attention to them. What was done was much less important than that something was being done.

The fourth kind of experiment is one in which the subject is destroyed by the experiment. The testing of explosives is an obvious example. Many biological experiments are of this kind. And gastronomical experiments of course always end that way. Cooking, by the way, is one of the fine arts in which experimentation is essential and well developed. In line with some of the comments I made earlier it would be interesting to see whether there are any great chefs left in Russia or whether there were any in Nazi Germany. It is probably not accidental that France, with the most individualistic revolutionary tradition, has without doubt the finest food.

I said when I began this discussion of the nature of experiment that it was preliminary to a consideration of an objection to the use of the experimental method, or rather a doubt that the experimental method can be used, in the social or political sciences. Even Norbert Wiener towards the end of his book *Cybernetics* sounds this pessimistic note: "With all respects to the intelligence, skill, and honesty of purpose of my anthropologist friends, I cannot think that any community which they have investigated will ever be quite the same afterwards. Many a missionary has fixed his own misunderstandings of a primitive language as law eternal in the process of reducing it to writing. There is much in the social habits of a people which is dispersed and distorted by the mere act of making inquiries about it. . . .

"On the other hand, the social scientist has not the advantage of looking down on his subjects from the cold heights of eternity and ubiquity. It may be that there is a mass sociology of the human animalcule, observed like the populations of

Drosophila in a bottle, but this is not a sociology in which we, who are human animalcules ourselves, are particularly interested. We are not much concerned about human rises and falls, pleasures and agonies, *sub specie aeternitatis.* Your anthropologist reports the customs associated with the life, education, career, and death of people whose life-scale is much the same as his own. Your economist is most interested in predicting such business cycles as run their course in less than a generation; or at least, have repercussions which affect a man differentially at different stages of his career."

From the examples I have already cited it is clear that the problem of interaction of observer and subject is really a serious one. One wonders, for example, how many of the people approached by an opinion poll form an opinion only because they have been asked to; or how many of those who said they had no opinion had been embarrassed by that and had gone back home to develop an opinion. The interaction of the observer and the subject may complicate life for the observer but it may be beneficial to the subject.

This interaction by no means makes impossible the use of experimentation. It is only necessary to be aware that the interaction exists and to make corrections for it. Essentially the observation becomes a part of the experiment and in extreme cases may even be the experiment. An investigation of the effect of poll taking on public opinion is a legitimate experiment and one in which the poll takers have already done considerable work. In electronics, feedback is an analogous reaction, but far from trying to avoid feedback in electronic systems it is often made use of to good advantage.

It is true that artists and physical scientists have a considerable advantage over social scientists in that their subject matter is more inert or less individualistic. Very often

it is not affected by the experiment. When it is affected it is either reversibly changed so that it can be converted back to its original condition for another experiment or else it is only one of a great number of identical specimens so that it can be discarded and further experimentation be done with its duplicates.

Nevertheless it seems to me that useful experiments can be performed in the social sciences. It is not necessary to relapse into the certainty of dogma or authority. There is in fact one characteristic of the subject matter which is to the advantage of the experimentally minded. Living organisms, whether they are biological or social, are constantly changing spontaneously. It is therefore possible for the observer to analyze these events as though they were experiments even though he did not plan or conduct them.

This technique might be called experimental thinking, in which one would try to see what hypotheses would best be satisfied by the events in progress. Then one would try to extrapolate the future consequences of such hypotheses and develop one's opinion accordingly. This of course is more or less what the normally intelligent citizen does consciously or unconsciously. I only recommend that it be done consciously and analytically, that some of the other techniques of scientific method be applied. The weakness of the scientist when he leaves his field of expertness is not in the methods he tries to use; it is due to his neglect of important non-scientific variables, moral, ethical, aesthetic, and psychological, and to his disregard of the feedback effect.

Although uncertainty may be a good, and its cultivation a virtue, indecision is a vice. Uncertainty should be one of the bases for decision, not an excuse for not making one. Uncertainty merely provides alternative decisions. Intelligence can then aid in the choice among them.

The Phi Beta Kappa is a society of scholars. Knowledge, not certainty, should be the objective of scholarship. It is not accidental that the publication of the society is called *The American Scholar* and that its subtitle is "A Quarterly for the Independent Thinker." Only in a complete anarchy could one have certainty and independence simultaneously, for there each individual would ignore every other individual, his ideas and his actions, and each could be quite certain that he was right. But independence is essential to democracy. The scholar should be the vanguard of independence. To be in the vanguard is always dangerous, but democracy is depending on its teachers and scholars.

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